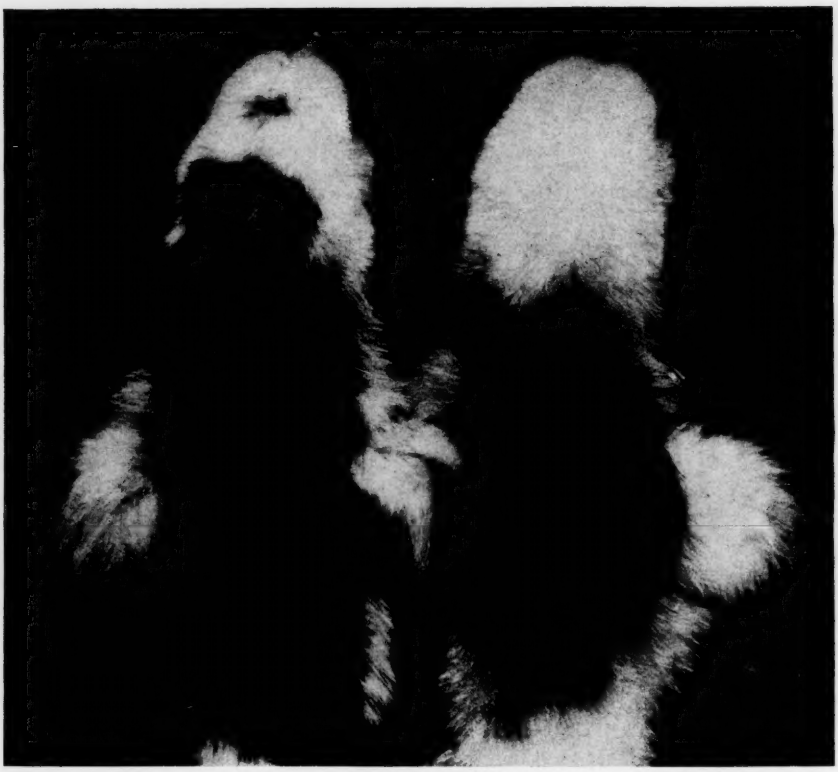
The Journal of HEREDITY



HEAD-SPOT AND BLACK BACK MARKS THE FEMALE

(SEE PAGE 221)

The Eucalyptus—Plant Immigrant Extraordinary

Chromosome Homologies in Timothy Hybrids

Four Generations of Double Joints

Coat Color in Horses

VOLUME 32 JULY, 1941 NUMBER 7

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

Journal of Heredity

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CONTENTS

MEYER MEDAL AWARD FOR EUCALYPTUS INTRODUCTION 211

THE EUCALYPTUS IN BRAZIL
By Edmundo Navarro de Andrade 215

THE AUTOSEXING ANCOBAR
By W. F. Lamoreux 221

CHLOROPHYLL-DEFICIENT SEEDLINGS IN TIMOTHY
By H. Wexelsen 227

HYPERMOBILE JOINTS IN ALL DESCENDANTS FOR TWO GENERATIONS
By Paul D. Sturkie 232

THE INHERITANCE OF EQUINE COAT COLOR
By G. W. Salisbury 235

Notes and Reviews

MEETING OF SCIENTIFIC PHOTOGRAPHERS 226

COMING

GENETICS AND RACE

In 1784 Herder said of human races: ". . . In short there are neither four nor five races, nor exclusive varieties of each on this Earth. . . . They belong not, therefore, so properly to systematic natural history as to the physico-geographical history of man." Since that time cephalic indices have been wild in the game of race with results that must have made old Herder spin in his grave. In certain quarters today we even have the crowning absurdity of "non-Nordic Norwegians" and "honorary Nordic Japanese." With race becoming politico-geographical, genetics may help to clarify very muddy waters.

HOMO'S GENES

A sex-linked fingerprint pattern—A dental anomaly in a Japanese family—Twins and the study of delinquency—The "Catlin Mark," a defect in the parietal bones—A pedigree of polydactyly—Studies of race-crosses in Hawaii.

GENES ELSEWHERE

A trisomic grasshopper—Galyx chromosomes, a study of cytology and economics—Genetics of the Palomino horse—The chromosomes of sheep—"Knotted" maize—A revised cygenetic map of the third salivary chromosome of Drosophila—Genetics of reversion.

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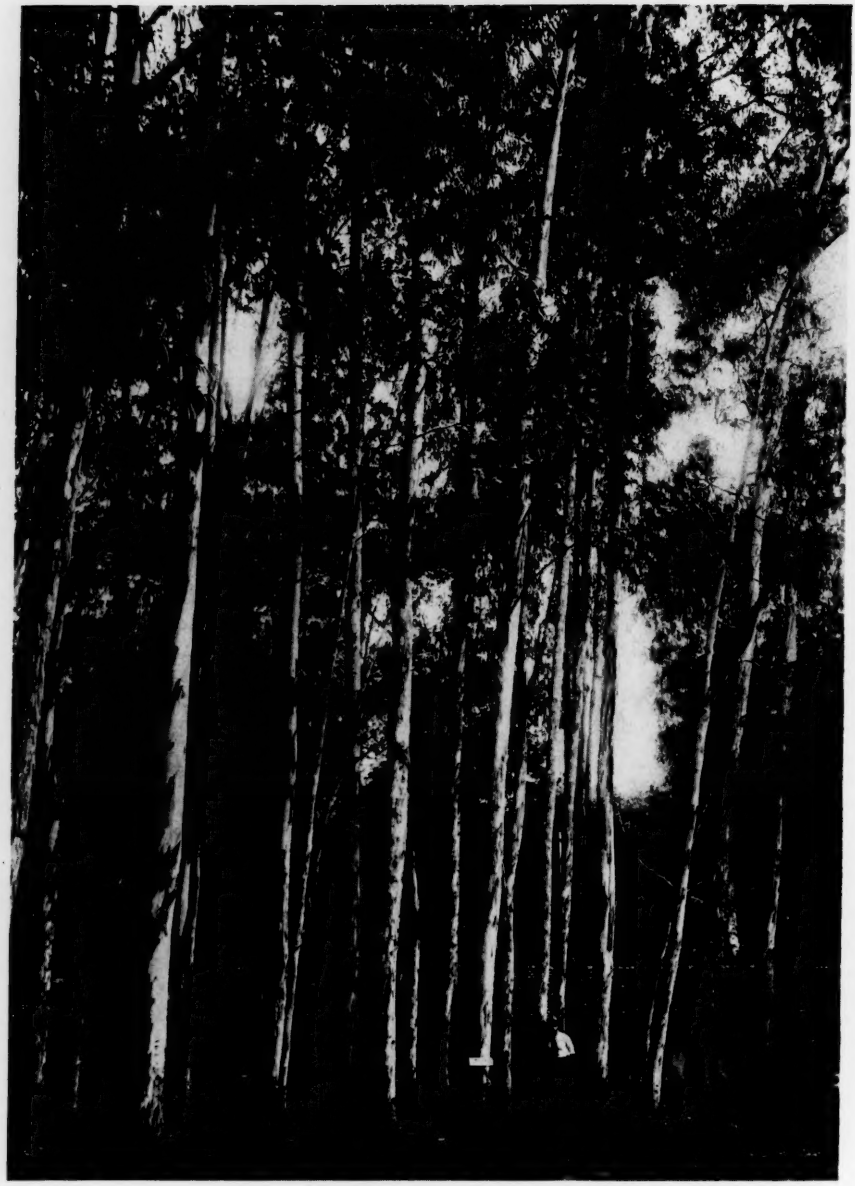


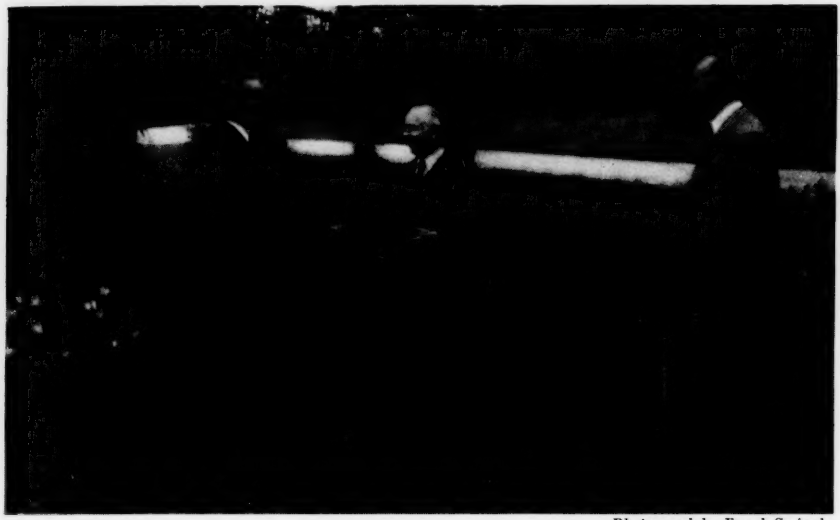
TWENTY-ONE YEAR OLD EUCALYPTUS

Frontispiece

A planting of *Eucalyptus maideni* twenty-one years old at the Rio Claro Experiment Station of the Paulista Railroad in the State of São Paulo, Brazil. This is one of the more valuable of the 150 species tested at this Station in the last thirty years. Of these species 25 have been found to grow excellently in Eastern Brazil and five are now being used in the very extensive plantings being made by the Paulista Railroad. This Railroad has at present twenty-one million trees and is planting 2,500,000 trees a year until a total of thirty-five million is reached.

AWARDS FOR EUCALYPTUS INTRODUCTION

Seventeenth Meyer Medal for Distinguished Services in Plant Introduction Awarded to Dr. Edmundo Navarro de Andrade of Brazil



Photograph by Frank Swingle

PRESENTATION OF THE MEYER MEDAL

Figure 1

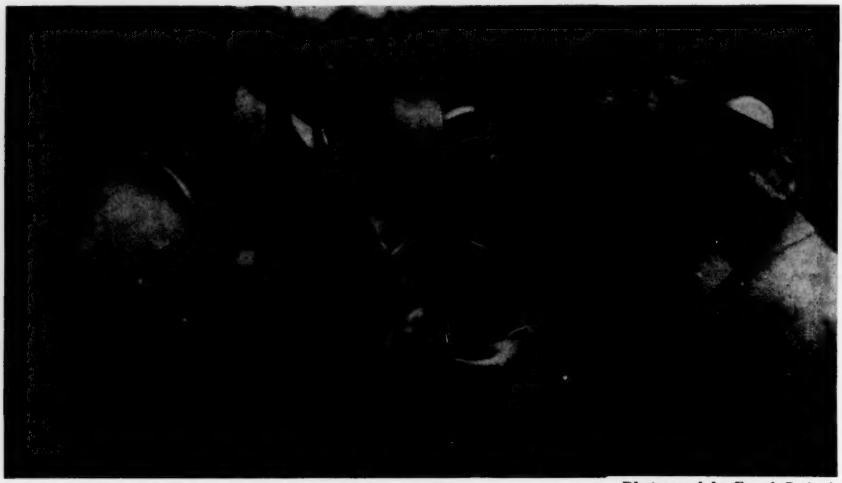
Dr. Navarro de Andrade has just accepted the Medal from the hands of Mr. B. Y. Morrison as Minister Lins de Barros looks on. The tree which is the background of this picture is an oriental species of oak (*Quercus acutissima*) growing on the grounds of the U. S. Plant Introduction Station at Glen Dale, Maryland. Under its branches the Meyer Medal was presented to Mr. P. H. Dorsett in 1935, and it was scheduled to be the scene of the presentation of the Medal to Dr. David Fairchild in 1939, when rain made a last minute change of plans necessary.

THE Meyer Medal for outstanding achievement in the introduction and utilization of Eucalyptus in Brazil, was awarded on June 2, 1941 to Dr. Edmundo Navarro de Andrade, chief forester of the Paulista Railroad of the State of São Paulo, Brazil. The presentation ceremony took place on the grounds of the Introduction Station of the U. S. Department of Agriculture at Glen Dale, Maryland. Mr. B. Y. Morrison, Chief of the Plant Introduction Section of the U. S. Department of Agriculture, made the award on behalf of the Council of the American Genetic Association and of the staff of the division of Plant Introduction. Among those present at the presentation were many distinguished members of the Botanical Services of the U. S. Government. Mr. Lins de Barros, newly appointed Brazilian Minister to Canada, flew to Washington from Ottawa to be present at the ceremony.

Following the presentation of the Medal a dinner was held in Dr. Navarro's honor at the Cosmos Club in Washington. At this were present members of the U. S. Department of Agriculture, Council of National Defense, of the State Department, of the Society of Agricultural Scientists and of the American Genetic Association. Following this Dr. Navarro presented a summary of his work in a public address in the Auditorium of the Cosmos Club (published herewith, pages 215-220).

PRESENTATION OF THE MEDAL

Abstract of Remarks by Mr. B. Y. Morrison in presenting the Medal to Dr. Navarro de Andrade



Photograph by Frank Swingle

DR. AND MRS. NAVARRO DE ANDRADE

Figure 2

After the presentation Dr. Navarro shows the Meyer Medal to his wife. Dr. Anna Jenkins, Mycologist of the United States Department of Agriculture's Disease Survey, looks on, as does the Editor of the American Genetic Association's JOURNAL.

WE workers with plants are more fortunate than many who live in a troubled world. The plants with which we deal are real. Our friends in other countries send us seeds, or cuttings of the plants themselves, and these plants germinate or take root and grow in our plant introduction gardens; at least many of them do. A chosen few prosper and go out to cover thousands of acres of our farms or to add new beauty to our gardens. So we plantsmen in all parts of the world are bound together in a time of strife and disintegration by very real living bonds.

And better than that, the plants with which we deal are not the only things which travel from country to country. The people who send them to us travel too, and in the slow turning of the years those friends in distant lands who have sent us of their botanical best, themselves become uprooted and eventually arrive in Washington. Here persons who were only an abstract name scribbled or flourished at the bottom of a letter materialize as very real and charming people of flesh and blood. You, Dr. Navarro, have come to our shores several times before. It is always a pleasure to welcome you again and to learn from you of the great progress which is being made in Brazil in the arts and sciences based on plants.

In this harried world of today, it is especially fortunate that plants as well as people travel. For in the development of that western hemisphere solidarity which is so much in all our minds today, one of the important aids to any effective program of good neighborliness must be the development of non-competitive crops and products which can be grown in one part of the Americas to supply other regions in which that crop cannot be grown.

And to Brazil and her neighbors we will increasingly look for many vital plant products we now get from other parts of the world. These we must have if our defense efforts are to be successful. Oils and drugs and timber of many special kinds will be needed.

Those who know you well realize that you are an authority on the culture of many important Brazilian crop plants. But today we wish to talk to you about our own especial favorite. Many years ago a far-sighted leader in your country recognized that supplies of fuel and timber were going to present an increasingly urgent problem in a country where no large deposits of good coal are available. So when you returned from Portugal with a degree and an urgent interest in botany, he appointed you to do something about this. You did, and this doing has continued for all of your days.

As a result of that doing you planted many large experimental forest plots of a great variety of species of Brazilian trees and of trees from other countries. You became convinced that to furnish quick supplies of fuel and timber one group of trees was overwhelmingly the most promising. That was the Eucalyptus tree from Australia. So you planted all of the species of Eucalyptus you could get your hands on by correspondence, and then you travelled to the countries where Eucalyptus was grown to get more. And eventually you went to Australia, the native home of the Eucalyptus, to learn all that you could about this large and diverse genus.

The upshot of all this is that today you have in Brazil the largest collection of Eucalyptus species to be found in one place anywhere in the world. Not only that, but you have changed the face of the Brazilian landscape over large areas with huge Eucalyptus forests which furnish vast quantities of fuel and increasing yields of timber for your country's needs. Later we are going to hear from your own lips the details of your work with this beautiful and valuable genus of plants. In recognition of this surpassing venture in plant introduction and utilization, it gives us great honor to award to you the Meyer Medal for distinguished services in plant introduction. In behalf of the Council of the American Genetic Association and of the staff of the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture, it gives me great pleasure to make this award.

DR. NAVARRO DE ANDRADE'S ACCEPTANCE

Mr. President, members of the Council of the American Genetic Association, ladies and gentlemen:

You must excuse my few words in imperfect English. I am a man of action, a forester, who has spent much of his life alone among Eucalypts, away from the constant chatter of the inhabitants of cities. I like to talk; I am even a talker, but not capable of making speeches. There is a big difference. Everyone must also remember that there are three things a man can do well only in his mother tongue: be angry, make mathematical calculations and express his heartfelt feelings. That is the reason I cannot find words to tell the distinguished members of the American Genetic Association my gratitude and to thank them for the great honor I receive with this award.

The first award of my technical career I received from the hands of Don Manuel, King of Portugal. It was the Christ Cross, given as a reward for my work in connection with the sand-dunes of Portugal. Years ago, in 1928, the Societe National d'Acclimatation de France gave to my Forest Service "la grande medaille hors concours de Saint-Hilaire." I now receive the Meyer Medal from the American Genetic Association as the finest reward of my long forester's life, and nothing could be a more pleasing climax to my hard-fighting career.

FOUR YEARS' GROWTH

Figure 3

These three photographs show three views taken along a road on the Rio Claro Experiment Station showing a planting of *Eucalyptus tereticornis* taken at one year old, two years old, and four years old. This is one of the best species for growth in the State of São Paulo. Such plantings would be used for locomotive fuel in the seventh year.

TRANSPLANTED FOREST

Figure 4

A wood cutter in a Eucalyptus forest at the Rio Claro Experiment Station at São Paulo. This Station covers some thirty-six square miles and has one of the oldest forests of the mass plantings initiated by Dr. Navarro. Some five hundred square miles of Eucalyptus forest now are growing in the State of Sao Paulo.

It would be interesting to tell you about my struggle to introduce the Eucalyptus for the afforestation and reforestation of my country and of my State against a ridiculous nationalism that fought any foreign tree. It would be an amusing story. I prefer not to tell it now, but to wait another opportunity in the auditorium of the Cosmos Club this evening.

There is one thing, however, that I must say to you now. When, for the first time, in 1910, I came to the States to improve my knowledge of Forestry with you, I received letters of introduction to scientific people from my old and very dear friends, Dr. David Fairchild and Dr. Walter Swingle. They introduced me to their friends as a "Brazilian authority on Eucalyptus." This I knew was not the truth but a graceful encouragement. I resolved to work to make it true, however, and I have done so for many years, in order not to disappoint my great friends. Receiving now from your hands the Meyer Medal, I feel that my friends' prophecy came true and I am immensely proud of deserving such a wonderful title.

How can I express here my gratitude for the great honor and the extraordinary award? Simply by thanking you, and again thanking you with all my heart.

THE EUCALYPTUS IN BRAZIL

EDMUNDO NAVARRO DE ANDRADE

"DR. NAVARRO: Why was it that you selected the Eucalyptus for the work of reforestation by the Paulista Company and not some other tree? Why did you give preference to an exotic tree, when, in the Brazilian flora, there are famous timbers so numerous?" I have been asked these two questions for so many years by so many hundreds of people that I wish to take advantage of this fortunate occasion to give you a definite reply.

Upon returning to my country from Europe, at the end of 1903, a graduate of the College of Agriculture of Coimbra, Portugal, I was invited by the Paulista Railroad Company to organize and direct the first forest plantation that it intended to create along its railway lines. The Paulista Company foresaw with notable vision that in the not very remote future there would be a shortage of firewood, posts, ties and timber, and, judging by the improvidence with which the native forests were being utilized, without anyone thinking of any reforestation.

When taking charge of that place, in December 1903, the first position I ever had and which I still hold, my spirit had no preference for any tree and I had no sympathy nor antipathy for any of them. My first care was to secure the greatest possible number of arboreal species indigenous and exotic for the purpose of trying them with all possible scientific rigor. For five years alone and without publicity I applied myself to this task, performing a considerable series of experiments, establishing nurseries and a great number of experimental cultures. Among the trees that were tried were some species of Eucalyptus, whose seeds I had brought from Portugal, and others from seeds that I had collected from trees planted in S. Paulo, which were used chiefly as shelters, windbreaks or ornamental trees.

For a long time I had been impressed by the extremely slow development of nearly all the Brazilian trees, especially those most famous for their timber. There was a deep rooted idea in my country that the slower the growth of a tree the better its lumber; an idea, like so many others, completely disproved by the Eucalyptus.

If my work had dealt with simple reforestation to cover poor or uncultivated soil, or with the creation of protective growths, or even of Government work of unlimited duration, the slow development of Brazilian trees would not have been an embarrassing obstacle. Instead, it dealt with a private business, an industrial enterprise and the creation of forests capable of furnishing definite and determined products in periods not long, but of economical duration. It would not be possible nor reasonable for a railroad that was going to need fuel wood, stakes, poles, posts and ties in a few years to plant trees whose utilization could only be realized upon their reaching a century of age.

Six years of patient study and hard work were necessary to reach plausible conclusions, always with the fear of making precipitate resolutions in a field of Agriculture, Sylviculture, in which time is measured by decades and in which the life of trees is counted in centuries. It was this that led me to propose to the Paulista Company that they enlarge our field of action and experiment, making the culture of experimental plots on a large scale and starting plantations of some species that seemed favorable to me. To this end there was acquired in 1909 a large agricultural tract in Rio Claro. This contained more than 6,000 acres and became the seat of my work. My studies there were the origin of and stimulation to the planting of tens of millions of Eucalyptus growing today in my State and in nearly all of Brazil. In S. Paulo

alone there must actually be about 100,000,000 of these precious trees growing today, and almost as many more disseminated throughout the rest of the country. At the time when I went to Rio Claro I could already depend upon seventy-two species of Eucalyptus, eighty-three of Brazilian woods and a large number of American, European and Australian trees.

Knowing of the development that the culture of Eucalyptus was having in the United States, principally in California, I came here to gain knowledge and with the hope of obtaining new species. It was thus I had the good fortune of visiting your admirable country for the first time in 1910, and I date from this time the good friendships that I made in the Department of Agriculture and in the Forest Service.

Unfortunately I learned little about Eucalyptus, but rather gained the impression that Eucalyptus culture was more thought of as a purely commercial enterprise than as a scientific undertaking. It seemed to me that it was more a proposition of selling lands planted with Eucalyptus than a study of the problem of culture and use on a scientific foundation.

Three years later, in 1913, I was sent to Australia, almost exclusively the native home of the genus Eucalyptus, and where the greatest authority on the subject was living. He was Prof. J. H. Maiden, Director of the Botanical Garden in Sydney and the author of *Forest Flora of New South Wales* and of the monumental *Critical Revision of the Genus Eucalyptus*. I had the rare good fortune of working privately with Prof. Maiden and of clarifying, with him, obscure points in the problem that interested me so much. Besides a most valuable herbarium, the noted scientist gave me a collection of seeds of 130 species of Eucalyptus which he considered would be best adapted to Brazil, some of them entirely unknown in my country. Of these I retain today 100 increased by others obtained in Algeria, especially the hybrids obtained from Dr. Louis Trabut, and by some obtained in South Africa, until there are now 123 species of this extremely rich genus actually represented in the cultivation of the Paulista Company.

From 1918 to 1926 on numerous voyages I traveled over the whole world, to its five continents and I can say today without fear of exaggeration that I have visited all of the countries in which Eucalyptus is cultivated, even on a small scale. I carried seeds from all these countries to S. Paulo and could make very interesting experiments upon the development and adaptation of the different species according to the origin and source of the seeds. Thus for example I could demonstrate that one of the species, *Eucalyptus gonicalyx*, always developed poorly when obtained from seeds native to Australia, but on the contrary, always gave magnificent results when the seeds were brought from California.

I shall be excused if I tell you that not all species gave satisfactory results. Of the 130 that I received from Prof. Maiden, 25 are of the best and 50 others are good. The others were all of little cultural value. An interesting fact that I have observed is that species originating in Western Australia have been, without exception, failures in Brazil, a country situated on the Eastern coast of America. These same species have given good results in Chile, Mexico, California and Cape Colony—all regions of Western situation on their respective continents.

Opposition to the Use of Eucalyptus

A phenomenon difficult of interpretation occurred shortly after the Paulista Company selected the Eucalyptus as a tree adequate for its purposes. There was initiated against these trees the strongest and most vigorous campaign of which there is memory in the field of Agriculture in Brazil. Any initiative, even the most daring, is habitually received with applause, or at least expectant sympathy in new countries, until it has been proved devoid of good sense. With Eucalyptus it was quite the contrary. It was received with fire

and sword, like an undesirable foreigner in whom all the defects were recognized and in whom all virtues were denied. This would have been comical if the best years of my life had not been spent in this campaign in a country whose principal wealth lies in the culture of coffee, an exotic plant; a country which did not know how to defend the wealth it possessed in rubber, the most native of national trees.

At the end of the past century Eucalyptus awakened enormous enthusiasm in the various countries whose climate seemed favorable to its cultivation. France, Italy, Spain, Algeria and Egypt carried on much propaganda in favor of this Australian tree. California, the Hawaiian Islands, South Africa, Argentina and Uruguay also started large plantations. However, the enthusiasm cooled and only the Union of South Africa and two or three other countries continue the cultivation with the original enthusiasm. Why? I am firmly convinced that in the great majority of these countries there was lack of a scientific foundation, of technical character of the work, and chiefly a lack of tenacity and continuity in the studies. I attribute the enormous result obtained by the Paulista Company to the fact that I lived, undismayed, as the personal head of the work for thirty-eight years, without a single break in the continuity of the work. The great merit of this undertaking lies in the fact of having studied Eucalyptus exhaustively from the cultural phase to its utilization, and what is more, in all its possible applications. Our experiments were performed in a great variety of climates and soils and were always made on a considerable scale.

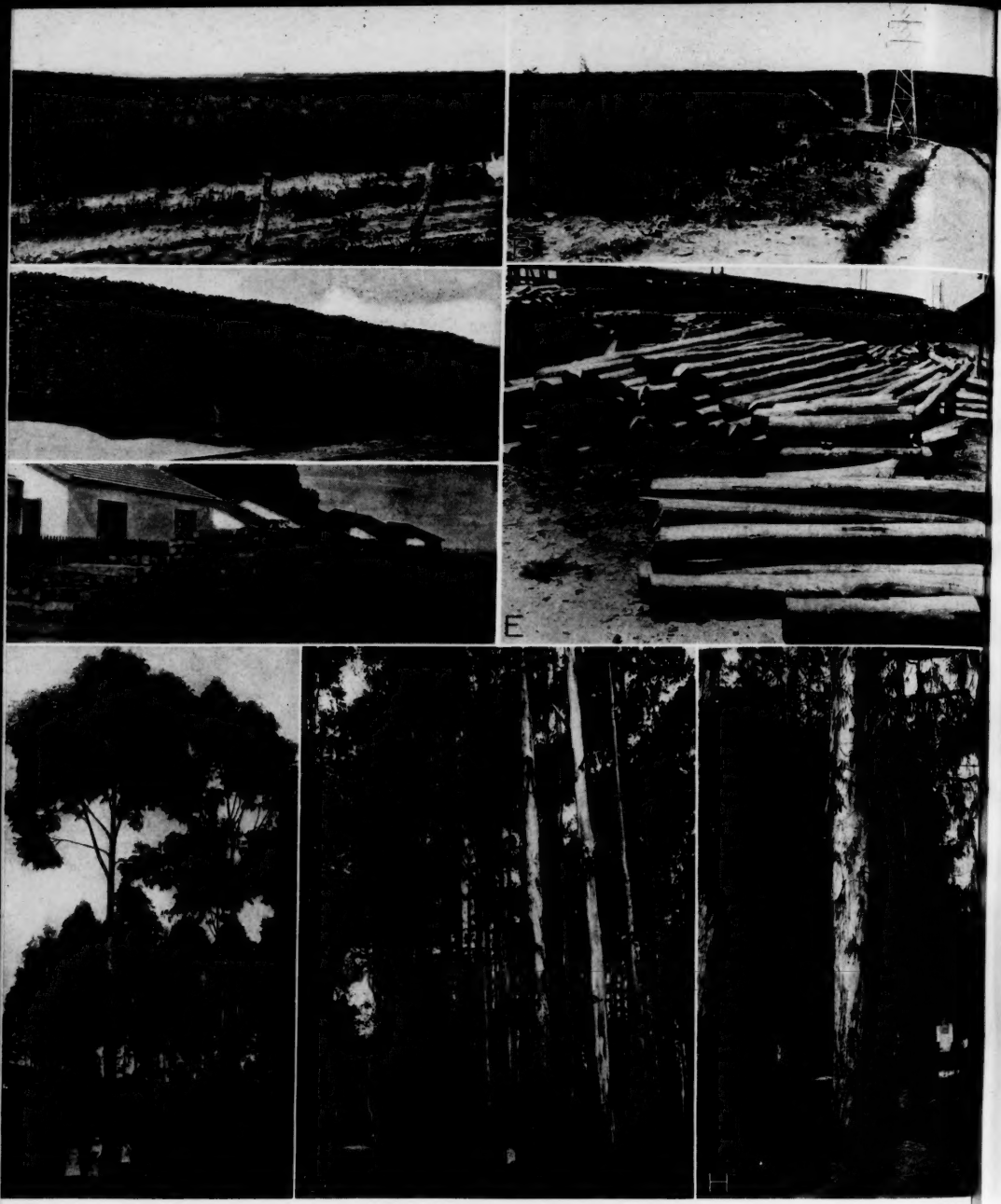
The Eucalyptus was submitted by me to all possible and imaginable tests, always under the eyes of the native critics. I always worked under the full fire of the enemy's batteries. Everything I used to do or to try was a reason for censorship always coming from those least familiar with the matter.

An example will show better the atmosphere in which I worked. Everyone was against me because I decided to adopt eight feet as the maximum distance between the trees, finding however, that the distance of six and a half feet was preferable. The world collapsed. Everyone thought that the Eucalyptus, owing to the rapidity of its growth and in order to develop its crown, should never be planted at less than 16 feet, even having people advising, in newspaper articles, the distance of 33 feet! Facing the general clamour, the Paulista Company itself became alarmed that I was wrong. There was only one practical means of convincing them and this was the one which I used: I began experimental and comparative cultivations of the same species, on the same soil, with the same cultural treatment and also on the same day, keeping a distance of two, three, four, five, and six meters between the trees. After seven years, I made the first cutting for fuel; five years afterwards, a new cutting; and after another seven years the third cutting, which culminated a patient awaiting of the results for almost 20 years.

Result: at six meters we got, in the three cuttings, 22 cords per acre, or a little more than seven cords per acre in each cutting; at two meters we obtained 120 cords per acre or 40 cords per acre in each cutting,—practically six times more than with the maximum spacing. And in this way, I had to go, step by step, slowly overcoming the resistances and bad faith and fighting ignorance.

I must confess, and I make the confession with the greatest pride, that I was victorious because I had as a support the privileged intelligence of a superior man, a real genius, Counseler Antonio Prado, the president of the Paulista Railroad Company, who with strong convictions always supported me.

Such respect I created for my work, such faith I have put in my success that my family used to say that besides the Eucalyptus nothing else, in this world, was of interest to me. One day, my mother, jokingly told me that I could



EUCALYPTUS IN BRAZIL
Figure 5

Views showing culture and utilization of Eucalyptus in the State of São Paulo, Brazil. *A*—shows the character of the vegetation in the regions reforested with Eucalyptus. This is cut-over country which years ago supported a rich and extremely varied forest flora. *B*—is a general view of the São Carlos Eucalyptus Plantation, one of seventeen great Eucalyptus forests maintained by the Paulista Railroad. The remaining photographs show scenes in the Rio Claro Eucalyptus Forest, which is the oldest and one of the largest in Brazil. *C*—shows a pile of Eucalyptus fire-wood to be used for fuel by the Paulista Railroad, containing 6,483 cubic meters (1801 cords). *D*—shows Eucalyptus ties piled to be measured. These are made from trees at least twenty-five years old. Poles and piles (*D*) are the third large use to which Eucalyptus is put. The wood is resistant to decay and to the teredo which is so destructive to marine piling. The wood is usually treated chemically if it is to be placed in contact with the soil. *F*—shows a planting of different species of Eucalyptus. The large tree in the foreground is a specimen of *Eucalyptus saligna* only six years old. *G*—is a planting of *E. tereticornis* thirty years old. A seventeen year old tree of *Eucalyptus virminalis* is shown at *F*. It is nearly three feet through.

even know the weight of the leaves which fell from the Eucalyptus. "That's one thing," I told her, "I have yet to learn and I'll do it." And for eight years I carefully weighed the leaves which fell on an area previously prepared. I could verify that the Eucalyptus enriches the soil with the falling of leaves, little branches and fruits, with an average weight of 12,500 pounds per acre per year.

After the great plantings of the Paulista Company had given rise to trees of 100, 120 and 150 feet in height and two to three feet in diameter, no one could longer deny the prodigious and rapid growth of Eucalyptus. There arose, however, a disbelief of its usefulness, of any employment for its timber, even though it were the most lowly use of wood, which is as fuel. The second phase of the campaign then began, longer than the first, and in which the time factor had greater relevance. It was necessary to demonstrate, and this the years have proved abundantly, that the wood of Eucalyptus could be applied in any and all services in which any other wood could be employed. I judge myself very fortunate to have been allowed to live and endure long enough to see the completion of my work. Today I can declare with all certainty that which has for a long time seemed to me a great truth—Eucalyptus is the only tree yielding first quality wood that can be utilized by the same man who planted it. This is the thesis that I expressed at the beginning and that the work of the Paulista Company goes to confirm.

Wood for Fuel

The first application that we made of Eucalyptus was as firewood for the locomotives of our own company. I may explain that wood is the fuel most employed by the railroads of my country. Brazilian coal cannot be compared with the foreign coal, the importation of which would be a financial burden. From 1915 to 1925 innumerable experiments were made with the wood of various species of Eucalyptus in order to clarify this point definitely. The results exceeded expectations, even the most optimistic, and since 1927 the Paulista Company has been using Eucalyptus on a large scale for locomotive fuel. Its Forest Service has delivered to the locomotives about 2,000,000 cubic meters (560,000 cords) of Eucalyptus firewood, which is the equivalent of 250,000 tons of coal.

In our next step we used Eucalyptus as fence posts. The railroads of Brazil are obliged by law to fence their right-of-way and as the Paulista owns about one thousand miles of line it is easy to imagine the number of fence posts needed. The posts of Eucalyptus are largely employed for this use today, not only for new fence but also for replacements.

Identical experiments were made with piles for foundations and with poles for telephone, telegraph and electric service. In all these applications Eucalyptus bore itself admirably and it is today largely used for these purposes by the Paulista Company and the other railroad companies. Suffice it to say that its Forest Service has furnished the Paulista and other private enterprises 262,517 piles and poles of a total length of 1,100,000 meters.

Paper Pulp

Some years after these experiments we turned our attention to a trial of Eucalyptus in the manufacture of paper. Prior experiments made by the Australians seemed to have determined that Eucalyptus would not serve for the manufacture of pulp, neither mechanical nor chemical, either because of the shortness of its fibres or because of the texture or color of the wood. In 1925, for the third time I came to be with you and to ask your help in my work. I brought with me from Rio Claro four logs, two each from two species of Eucalyptus, from trees thirteen years old which I had planted. The necessary experiments were performed at the Forest Products Laboratory at Madison, Wisconsin, where I had the inestimable cooperation of all the scientists

of that famous institution and chiefly of my dear friend, R. N. Miller, who was working there in the section of Pulp and Paper. We obtained several qualities of paper from Eucalyptus including printing paper, which was contrary to general expectation. This latter served for a printing of a part of the edition of the *Wisconsin State Journal* of December 30, 1925.

In S. Paulo a paper mill of the firm Gordinho Brauns S/A has been working with cellulose or pulp from Eucalyptus since March 1927. Papers for writing and printing are made using 25-30% of bleached pulp from Eucalyptus. This plant also makes paper with higher content of Eucalyptus cellulose, reaching as high as 60%. It can be seen from this that all the applications of Eucalyptus wood that have been tried in S. Paulo have already advanced beyond the experimental stage.

The most important result realized by the Forest Service of the Paulista Company was, without doubt, the example and the provocative stimulation not only in S. Paulo but in the whole of Brazil. Today the Brazilian Forest Code compels all the industries that use wood as fuel to reforest the lands utilized in the proportion of 20% of their annual consumption of fuel wood, taking as an average a production of 100 cubic meters, or 28 cords per acre. However, long before the requirements of the Code, large utilization of Eucalyptus had begun in Brazil. In the state of S. Paulo all the railroad companies owned forest nurseries and plantations of Eucalyptus. The first to follow the example of the Paulista Company was the Mogyana Railroad Company, which actually has 11,000 acres of lands on which 5,472,000 Eucalyptus are already planted. The Sorocabana Railroad, belonging to the State of S. Paulo created its own service of reforestation and owns for this purpose a total of 5,512 acres and 3,592,000 Eucalyptus trees. The services of one of my assistants was requested to organize this Service, and he is still in charge of the work. The Araraquara Railroad Company, also belonging to the State of S. Paulo installed an identical Service two years ago and already has a plantation of 1,000,000 Eucalyptus trees and has acquired 19,170 acres of land for planting. Even a small company, the Itatibense Railroad has a plantation of 210 acres and 200,000 Eucalyptus for its locomotives. This company has only 12 miles of line.

It is not only in the State of S. Paulo that the influence of the Paulista Company makes itself felt. A sum of $135,000.00 in the budget of the Ministry of Transportation for the current year was set aside for the installation of forest nurseries on various Federal Railroads. These are Brazil Central, Northwest of Brazil, Goyas, Cearense Transportation, and Brazilian Eastern.

After the State of S. Paulo, the Brazilian State that has given the greatest impetus to reforestation is Rio Grande do Sul where there must be more than 40,000,000 Eucalyptus planted today. There also the railroad companies created departments for reforestation service many years ago and they maintain various plantations along their lines.

A curious and eloquent fact is noted in a late statistical publication of the Secretary of Agriculture of S. Paulo. For census purposes the State was divided into ten agricultural districts. In the districts where the forest plantations of the Paulista Company are situated the total of planted Eucalyptus covers 80.8% of all forest cultivations in S. Paulo, which demonstrates clearly the influence exercised by the work of that company. The Paulista Company actually owns 21,000,000 growing Eucalyptus and has acquired the land to increase this to 35,000,000 by additional plantings at the rate of 2,500,000 per year.

A problem remains for us to solve, however, and that is the use of Eucalyptus for ties. Because of the special structure of its wood, trees of less than thirty years of age and of diameter less than three feet split when sawed, and the ties have a tendency to crack

(*Continued on page* 240)

THE AUTOSEXING ANCOBAR

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THE term, autosexing, has been used to describe a pure breed in which there is some characteristic difference between the down colors or patterns of male and female chicks that enables one to determine their sex at the time of hatching. Such a pure breed was first planned and developed in England by Punnett and Pease,[6] who demonstrated that by combining the sex-linked genes for barring, found in the Barred Plymouth Rock, with the autosomal genes for barring present in the Campine, a pure breed could be obtained in which male chicks are somewhat lighter in color than females. This breed was named Cambar, and its sex-linked color pattern presumably results from the fact that the sex-linked gene for barring is an incompletely dominant inhibitor of pigmentation. Therefore, in the homozygous male, two genes for barring produce a lighter color of down than the single gene in the hemizygous female. This normal sex dichromatism as seen in the Barred Plymouth Rock is accentuated in the Cambar by the presence of the autosomal genes for barring found in the Campine.

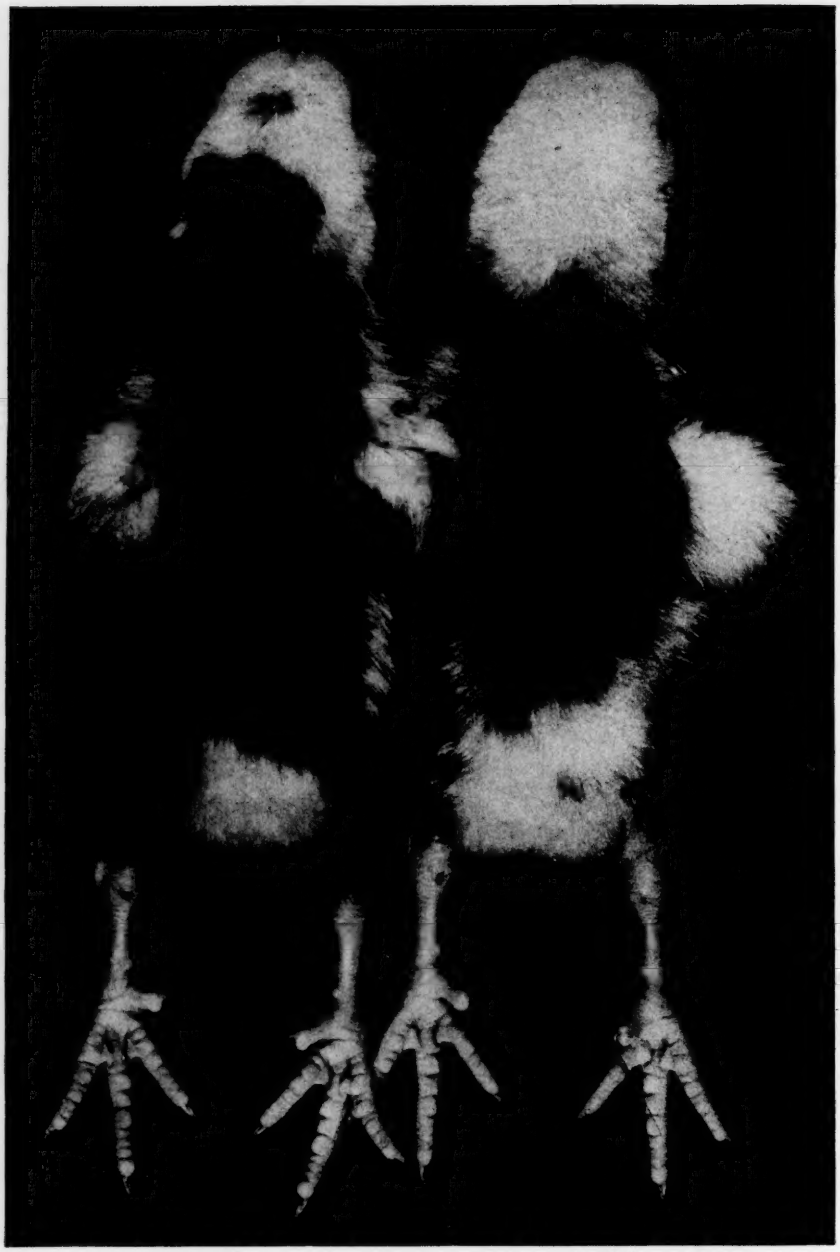
Since the Cambar was developed by several back-crosses to the Campine, a breed with a white skin and relatively poor in egg production, it seemed desirable to develop an autosexing strain that could be back-crossed to a more productive breed, and one that carries the yellow skin preferred in American markets. The better strains of Barred Plymouth Rocks are satisfactory for this purpose, but American-bred Campines are not. It was suspected, however, that genes which restrict or inhibit the formation of melanin to produce either mottled or spangled plumage might serve just as effectively as the autosomal barring of the Campine to accentuate the dichromatism between birds homozygous and hemizygous for the sex-linked barring gene. The mottled Ancona has yellow skin and, since the hens of some strains are fairly good layers, this breed was selected to be crossed with Barred Rocks in this experiment. In the F_2 generation, individuals were selected that would breed true for both barring and mottling. Such birds have been called Ancobars. A series of back-crosses to Barred Plymouth Rocks was then started to obtain mottled birds that are otherwise comparable to the Barred Rock. Preliminary results obtained with the Ancobars were reported by Lamoreux[4] in 1939, but since that time additional data have been obtained to show the degree of variation that exists in their down color and the accuracy with which the chicks can be sexed by means of differences in color.

Since this study was undertaken, similar autosexing breeds have been reported by Hagedoorn,[1] who added sex-linked barring to the Leghorn and Barnevelder, and by Jaap,[2] who has combined the sex-linked genes for gold, rapid feathering, and barring with desirable characteristics of conformation found in the Dark Cornish, to form the Oklabar.

Development of the Ancobar

To obtain birds carrying the sex-linked gene for barring (B) and the autosomal gene for mottling (e'), a mating of Ancona ♀ × Barred Plymouth Rock ♂ was made in the spring of 1936. Chicks that were both barred and mottled ($BBéé$ or $B_éé$) were obtained in the F_2 population, and were found to be much lighter in color than those heterozygous for the recessive gene for mottling ($E'e'$). These barred and mottled chicks, named Ancobars, were selected for further breeding.

In 1938, these Ancobar males and females were back-crossed to Barred Plymouth Rocks in order to obtain birds typical of the Barred Rock breed with respect to characters other than mottling. Several such back-crosses would of course be necessary to complete this process. The back-cross progeny were mated with Ancobars the following year,



A—Female *B—Male*

ANCOBAR CHICKS

Figure 6

At right is a male chick with the typical gray down over the posterior part of the back, and no head spot as compared with the female on the left. All chicks lacking black head spots are male, but many males have head spots.

giving chicks half of which were Ancobars, *i.e.* both barred and mottled.

Sufficient Ancobars were available in 1940 to make matings within the "breed." All progeny of such matings have been typical Ancobars in appearance and have been classified with respect to color and assumed sex at the time they were removed from the pedigree baskets of the incubator trays. In some instances, the chicks were killed and the actual sex determined by observation of the gonads immediately following classification. Other chicks were reared to an age when sex could be determined by means of secondary sexual characters.

Sex Dichromatism

Two characteristics of the down pigment have been found useful in distinguishing between the sexes.

(1) *Head spots.* Those chicks which lack a black head spot have, with one possible exception, been males (Figure 6*B*). The one exceptional chick has developed so abnormally that at 11 months of age sex cannot be determined either by the appearance or the performance of the bird.

(2) *Density of pigment on the back.* Nearly 98 per cent of the chicks with black backs are females (Figure 6*A*). The typical males have some black on their backs, but in most individuals the periphery, and especially the posterior part of the pigmented area, is gray rather than black. About 9.1 per cent of the chicks have been classified as having backs intermediate in color between those of the typical male and female illustrated in Figure 6. Among these intermediate chicks, males and females are equally represented and the group as a whole, therefore, contributes most of the error encountered in "sexing." Since all of these chicks with intermediate backs must be considered as females if one is to retain a maximum proportion of pullets, 4.5 per cent of the chicks in this study were incorrectly classified as females because of intermediate pigmentation.

A few of the chicks are very much lighter in color than the typical male shown in Figure 6, but such chicks invariably lack black head spots and are males.

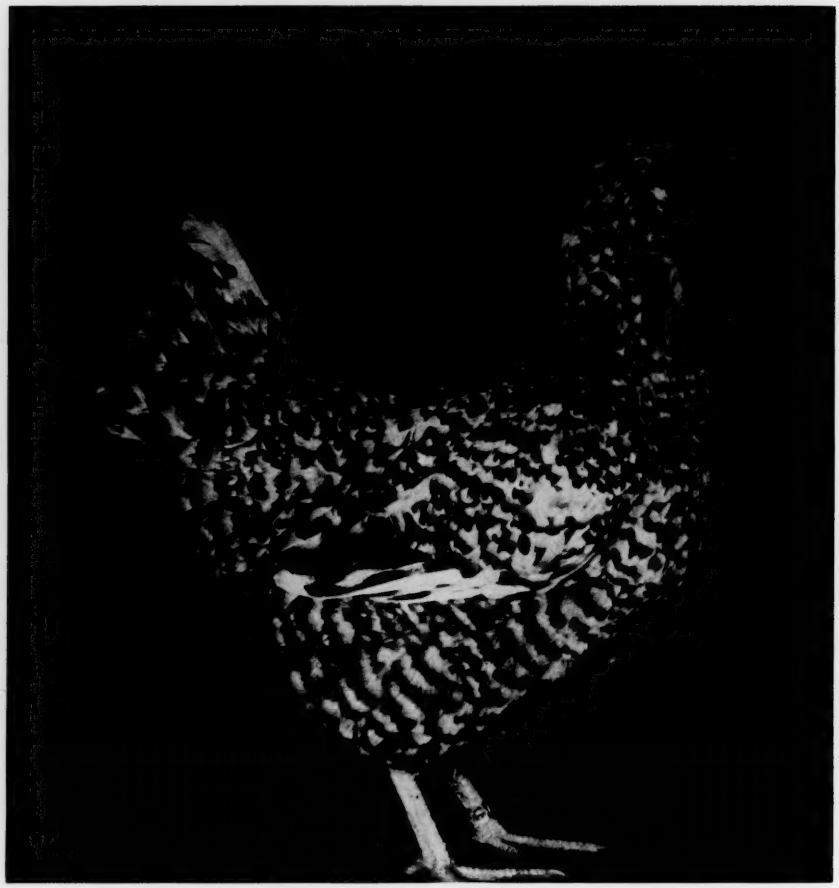
A tabulation of the classified chicks is given in Table I to show that sex can be determined correctly for more than 93 per cent of the chicks. Only three chicks among the 147 classified as having black backs were males, and four of 153 with light backs were females. Differences between the sexes appear to be more distinct in some families than in others, but further experimentation will be required to determine whether or not selective breeding can increase the accuracy of autosexing in the "breed."

In adults, the difference between the sexes with respect to pigmentation is still more pronounced than in the chicks. Fully feathered females resemble the Barred Plymouth Rock except that many feathers are mottled (bear white tips) and a few are white (Figure 7). The male, however, is a predominantly white bird with scattered and irregular black or gray bars on the feathers (Figure 8).

Discussion

All autosexing breeds that have been reported in the literature have utilized the sex-dichromatism resulting from use of the sex-linked gene for barring. Punnett and Pease[6] used it in the Cambar. Hagedoorn[1] describes its use in the autosexing Barnevelder and autosexing Leghorn. It is an essential part of the genotype in the Oklabar,[2] and recently Punnett[5] gave a complete description of its use in the development of the Legbar. This breed shows somewhat greater promise as an autosexing breed than the original Cambar because the Leghorn hens are somewhat better layers than the Campines. In 1939, the Legbar was recognized as a "standard variety" by the Council of the Poultry Club in England. Known as the Golden Crele Leghorn, it thereby becomes the first autosexing breed (exclusive of the Barred Plymouth Rock) to receive such recognition.

Since this study was undertaken, it has been shown that pure Barred Plymouth Rock chicks which are males, and



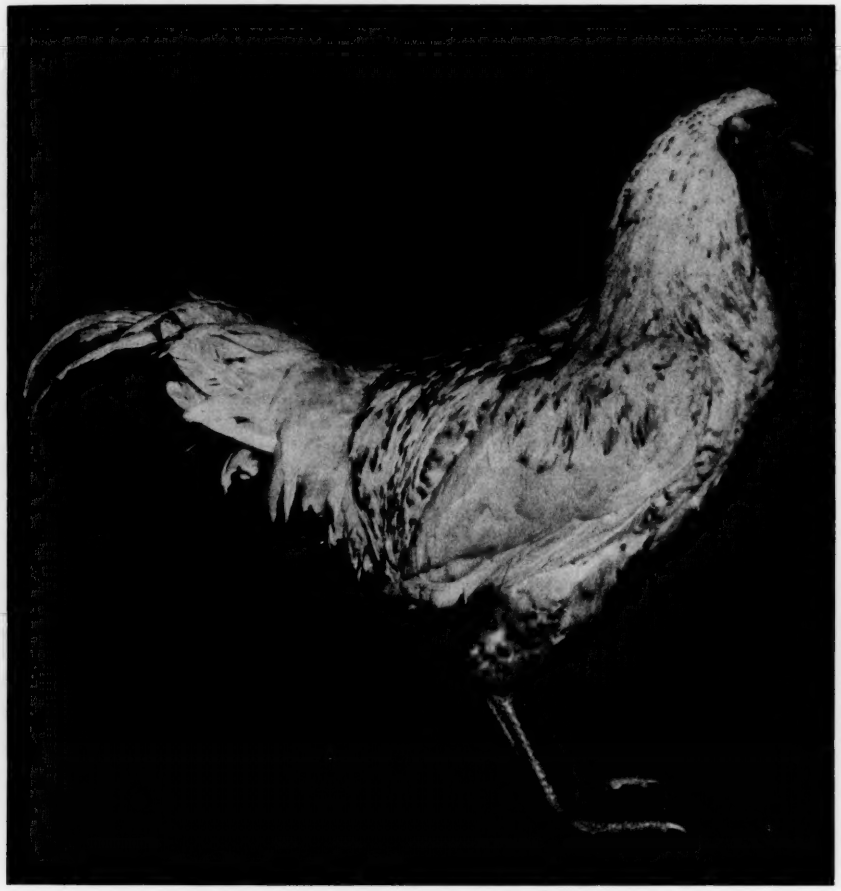
AN ANCOBAR HEN

Figure 7

The Ancobar female carries *one* sex-linked gene for barring (*B*–), and two autosomal genes for the Ancona mottling (*éé*). The interaction of the single barring gene and the two mottling genes give a darker pattern than the double barring constitution of the male (Figure 8).

therefore carry two genes for barring, are usually somewhat lighter in color and different in color pattern than the female chicks which carry only one of these sex-linked genes. Quinn and Knox[7] were able, by external characteristics, to determine the sex of more than 90 per cent of the chicks from some flocks. Jerome[3] found that in one strain the sex of 98 per cent of the chicks could be determined correctly by means of differences in pigmentation. Very few hatcherymen find it necessary to guarantee that their "sexing" is always correct, and these results show that autosexing of some of the established strains of Barred Rocks is accurate enough to be useful without genetic modification of their down color.

However, some strains of Barred Ply-



THE NEAR-WHITE ANCOBAR ROOSTER
Figure 8

The sex dichromatism of the Ancobar depends on the presence in the male of *two* sex-linked genes for barring (*BB*) and two autosomal genes for Ancona mottling (*éé*). The double dose of the barring gene results in a somewhat lighter down color and a distinctly lighter adult plumage than the female.

mouth Rocks apparently cannot be sexed with the high degree of accuracy indicated above, and some means of increasing their sex-dichromatism is needed. Results obtained with the different autosexing breeds suggest that the addition of any pattern (not dominant white) that reduces the amount of black in the plumage of the Barred Rock may also accentuate the difference in color between homozygous (*BB*) and hemizygous (*B*–) individuals. In the Ancobar, this makes it possible to utilize autosexing in a breed, the males of which are nearly white. Since such males are relatively free from colored pin feathers, they have the added advantage of being able to compete with white breeds in markets that discriminate against colored fowl.

Summary

From a mating, mottled Ancona ♀ × Barred Plymouth Rock ♂, chicks were obtained in the F_2 and back-cross generations that were both barred and mottled (*BBéé* ♂♂, or *B–éé* ♀♀). Among the chicks of such individuals, the males, homozygous for barring, are usually lighter in color than the hemizygous females. The females and a majority of the males have black head spots, while chicks lacking such spots are always males. In this study, more than 97 per cent of the chicks with light backs, or gray rather than black down around the periphery and especially the posterior part of the pigmented area of the back, were males. Among those chicks with black backs, 98 per cent were females, while both sexes were equally represented among chicks classified as intermediate in color. By means of these differences in down color, 93 per cent of all chicks were correctly classified with respect to sex at the time of hatching. The adult plumage is both barred and mottled in the female, but white with only scattered and irregular bars in the male.

Table I. The relation between color of down and the sex of Ancobar chicks.

Mating	Black backs		Intermediate backs		Light backs			
	Head-spots		Head-spots		Head-spots		No head-spots	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
Back-cross 1939	57	1	2	9	1	48		24
Ancobars 1939	31		9	3	3	10		7
Ancobars 1940	56	2	4	3		37		23
Total	144	3	15	15	4	95		54
	177 classified as ♀♀ error = 10.2 percent				153 classified as ♂♂ error = 2.6 percent			

Total of 330 classified chicks
error = 6.7 percent

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Meeting of Scientific Photographers

The Biological Photographic Association, an international group of photographers in the natural sciences, will hold its 11th annual meeting in the Hotel Buffalo, Buffalo, New York, September 11-13, 1941.

The program, in which a number of outstanding photographers and other technical experts will participate, emphasizes this year methods and processes which are likely to contribute to the national defense.

The annual salon, now well known to photographers through the pages of the photographic magazines, will again be a prominent feature of the meeting. Visitors are welcome.

For further information write the Secretary of the Biological Photographic Association, University Office, Magee Hospital, Pittsburgh, Pa.

CHLOROPHYLL-DEFICIENT SEEDLINGS IN TIMOTHY (*Phleum Pratense L.*)

H. WEXELSEN
Hjellum, Norway

EDITOR'S NOTE. *When Dr. Wexelsen transmitted this paper for publication, he requested that it be edited in this country without returning it to him because of the present uncertainties of transportation. Therefore, the paper has been edited by one of the reviewers, who writes as follows:*

"In addition to a few changes in sentence structure, the reviewer is responsible for a minor change in interpretation, specially in the discussions dealing with the possibility of tetrasomic inheritance. Although Dr. Wexelsen's original manuscript excluded this possibility, it seemed to the reviewer to be a more suitable explanation of the behavior of family F8-11 and its descendants. The cytological findings of Müntzing and Prakken[6] and Nordenskiöld[8] (these references had not come to the attention of the author and have been inserted by the reviewer) suggest that sufficient homology may exist between two genomes of hexaploid P. pratense *to permit bivalent formation between homologues from the two genomes. In addition, the reviewer has unpublished evidence that quadrivalents are formed at least in some plants of this species. These cytological results suggest that some characters may be found in* P. pratense *which show tetrasomic inheritance."*

CHLOROPHYLL-deficient seedlings have frequently been observed by workers engaged in timothy inbreeding experiments, but little is as yet known of the genetic basis for the appearance of these types. Chlorophyll-deficient seedlings in five out of eleven I_1 lines (I_1 = first selfed generation) were found by Hayes and Barker.[4] Chlorophyll-deficient seedlings appeared in 37 per cent of the lines examined by Clarke[2] and he suggests that three homomeric factors are involved in the inheritance of white seedlings. Valle[9] found white and white-green but no yellow seedlings in selfed timothy lines. Chlorophyll-deficient seedlings in timothy which are described as white, yellow, yellowish-green, and striated were observed by Nilsson.[7] These types occurred in various ratios in selfed and open-pollinated families, but genetic interpretation of the results was not possible. It was concluded, however, that in some families at least two factors were involved.

In a series of inbreeding experiments with timothy at Felleskjœpets Stamsedgaard, Hjellum, Norway, a large number of chlorophyll-deficient seedlings have appeared and sufficient data have been obtained to make clear the genetic basis of the various types.

The material consisted of plants selected from local Norwegian strains and from Swedish bred strains, isolated for selfing in the field by enclosing the heads in Pergamine paper bags. The seeds were sown in sterilized soil in pots and the seedlings transplanted to boxes. Some families had been grown from the same seed in two or three different years. A high degree of self-sterility was found among the plants but there was considerable variation in this character. Only families with a fairly large number of seeds were sown, and the material represents, therefore, a selection of the more self-fertile mother plants.

Albino Seedlings

These seedlings were a pure white color and were apparently of the same type as albinos described in maize, barley and other plants. The seedlings died soon after the food from the endosperm was exhausted. The segregation data are presented in Tables I and II. The first two families in Table I, 69-2 and F8-11 probably represent monohybrid segregations, although there are significant deficits of albinos. The following 19 families are interpreted as segregating in a 15:1 ratio. Here there was a rather large deficit of albinos, but a 15:1 segregation seems to be the correct interpretation of the data. Only one of the 19 families had a significant deficit, and there were 11 negative and 8 positive

deviations. In Table II are shown 24 families with a smaller percentage of albinos, representing probably 63:1 segregations. In the totals there was again a significant deficit of albinos, but only one family had a fairly significant deficit and there were 16 negative and 12 positive deviations. The deficit may have been due to lower viability, although this can not be proved. Of some families, seed produced from one year was sown in two and three consecutive years and at the later sowings a lower percentage of albinos was found in some of these (Table III). One and three years old seed from Grindstad was sown at the same time in 1939, but no difference was found between the old and the new seed. The differences at the various sowings may have been due to variations in germination. The albinos were slightly slower in germinating than the green, and adverse growing conditions may have affected them more severely.

It is concluded that the material contains three homomeric factors, each of which conditions, when heterozygous, normal chlorophyll development in the seedlings. The segregation in one family was not in agreement with this interpretation. Two plants, selected from Grinstad timothy, were crossed, giving family F8. Five plants of this family when selfed produced some albino seedlings and four were classed as segregating 63:1 (Table II). One plant produced family F8-11 (Table I) which segregated in a ratio of 3 green : 1 albino. Several plants of F8-11 were selfed but only four produced sufficient seed for sowing. Of these, two produced only green seedlings and two (families F8-11-1 and F8-11-3 in Table I) produced albino seedlings in ratios approximating 15:1. On the assumption of bivalent pairing, F8-11 should have been of the constitution *Xx* and should have produced only homozygous *XX* and heterozygous *Xx* progenies (in addition to the lethal albinos). The heterozygous plants would produce progenies in the ratio of 3:1. An alternative explanation can be offered for these seemingly anomalous results. On the assumption of pairing between chromosomes of the different genomes, the parent of F8-11 may have been simplex (*Xxxx*), in which case a ratio of 3 green : 1 albino would have been expected and this ratio was obtained. On this hypothesis, *XXxx* plants would occur in F8-11 and these plants would be expected to produce progenies in a ratio between 20.78:1 and 35:1. Families F8-11-1 and F8-11-3 may be of this type.

Yellow Seedlings (Xantha)

The yellow seedlings were pure yellow, apparently similar to the xantha seedlings in barley (Hallquist[3]) and the yellow seedlings described in maize and other plants. The yellow seedlings died at the same stage as the albinos. The segregation data are found in Table IV. Two families segregated in a ratio of 15:1 and seven families 63:1. In both groups there is a small deficiency of yellow. The segregation data for one family 601-1 sown first in 1934 and then again in 1937 gave only green seedlings and one yellow seedling, respectively, in a total of 416. The yellow seedling may have been a mutant, although the explanation of tetrasomic inheritance, discussed above, would also account for this seedling. The data suggest that there are three homomeric factors conditioning yellow seedlings.

Yellowish White With Green Streaks

This type resembles most nearly the description of virescens, but it is as yet too little studied. The segregation data are:

Family		green	yellowish white
808-1		122	4
50-1-2		67	9
		189	13
Expected	15:1	189.37	12.63

Yellow Green

The seedlings are of a yellow greenish color, distinctly different from the two described just previously. It is not lethal, the seedlings turning green. The segregation data are shown in Table V, showing 3 ratios, 3:1, 15:1, and 63:1. In the 3:1 segregations there is a small

deficit of the recessive; in the other two groups a small excess.

Light Green

These seedlings have a light green color without the yellow tinge of the yellow green former type. They are not lethal. The segregation data in Table VI show the same three ratios as the other types.

Some families have been segregating for two or more chlorophyll deficiencies and the data on these are found in Table VII. The expected numbers have been calculated on the basis of the segregation ratios of the single character, and independent segregation between them. Further, the supposition is made that the types with the stronger reduction of chlorophyll cover the types with the smaller reduction. On this basis the numbers found agree well with the expected, except in family F8-11, where the discrepancy is due to the deficit of albinos. It should be noted that although the four chlorophyll deficient types segregate independently, the possibility that some of them are on the same chromosome is not excluded because with a limited number of plants weak linkages cannot be detected in so wide ratios.

Discussion

In studies of hexaploid *Phleum pratense* ($2n = 42$), Müntzing[5] reported the regular occurrence of bivalents in meiosis and, on the basis of meiotic behavior of plants which he considered were hybrids of hexaploid with diploid *P. pratense,* he gave the genomatic constitution of the hexaploid as *NNAABB*. Recently, Nordenskiöld[8] and Müntzing and Praken[6] reported evidence of homology between two of the genomes and Müntzing and Prakken[6] have raised the question whether each set of four "homologues" in these two genomes form bivalents at random or in particular pairs. The former type of pairing would result in tetrasomic ratios for genes carried on these chromosomes, while the latter type would result in disomic ratios. Furthermore, if polyploidy is the basis of homomery and the latter type of pairing prevails, three homomeric factors should be found in hexaploid *P. pratense*. This point has been stressed by Akerman and Mühlow[1] in a study of the ligule character in oats.

It is of interest that the results obtained in this investigation in general can be interpreted most satisfactorily on the basis of three independently inherited factors conditioning each of the four chlorophyll deficient types.

On the other hand, use of the first segregating generation is not very critical for distinguishing between disomic and tetrasomic inheritance. Furthermore, the behavior in family F8-11 and its progeny can be explained most satisfactorily by assuming random pairing among the four chromosomes bearing the gene. Therefore, although the results reported here tend to support the hypothesis that bivalent formation regularly involves the same homologues, the possibility of random formation of bivalents among at least certain of the supposedly homologous chromosomes of the two genomes cannot be excluded.

Frequency of Albinos in Non-Inbred Populations

It would be of interest to determine the frequency of chlorophyll deficient seedlings in non-inbred and non-selected populations of timothy. The presence of homomeric factors makes an exact determination of the frequency of recessive allelomorphs very difficult, but a rough determination may be made in this material of the percentage of plants in the Grindstad strain giving albinos in their offspring, that is, the percentage of plants that are not homozygous dominant for any of the three genes. Even such a calculation will be uncertain, because many plants do not give enough seed to realize a 63:1 segregation and will give only green seedlings even if heterozygous. Of 70 Grindstad plants, 15 gave albinos in their offspring, that is, 21.43 per cent, but the number of plants capable of segregating albinos is probably higher. Of the 15 plants, 11 showed a 63:1 ratio, four a 15:1 ratio, and none a 3:1. Seed of Grindstad has been sown at various times and has given a total of

TABLE I. Albino seedlings in selfed timothy families.

Family	Mother Plant	Generation of selfing	No. seeds	% germination	Number of seedlings found green	albino	Expected albino	P
			3 : 1 segregations					
69-2	69	I_1			154	28	45.5	2.95
F8-11	$F8_9$	"	450	72.67	263	64	81.75	2.87
			15 : 1 segregations					
29-2	29	"			229	11	18.-	1.07
31-1	31	"			63	2	4.06	1.06
F11-1	$F11_{80}$	"			134	5	8.06	1.11
F13-1	$F13_{11}$	"			436	20	26.67	1.33
52-1	52	"	628	96.97	576	33	38.06	0.85
F60-1	$F60_3$	"	552	85.33	485	16	29.44	2.56
F61-2	$F61_{45}$	"	60	86.67	48	7	3.25	2.14
F63-1	$F63_3$	"	98	95.92	89	6	5.88	0.08
10-1-1 a	$10-1_{30}$	I_2			119	7	7.88	0.32
10-1-1 b	"	"	585	88.21	490	26	32.25	1.14
26-1-1	$26-1_{15}$	"			83	3	5.38	1.06
F5-1	$F5-1_{44}$	"	801	92.01	685	52	46.06	0.90
F8-11-1	$F8-1_{19}$	"	151	66.89	99	3	6.71	1.36
F8-11-3	$F8-1_{13}$	"	332	71.99	219	20	14.94	1.35
58-2-1	$58-2_{46}$	"	50	76.-	36	2	2.38	0.26
31-1-1	$31-1_{25}$	"	59	74.58	35	5	2.75	1.40
F14-1-1	$F14-1_3$	"	162	65.43	97	9	6.63	0.95
10-1-4-2	$10-1-4_1$	I_3	119	39.50	44	3	2.94	0.04
10-1-4-1	$10-1-4_8$	"	47	59.57	26	2	1.75	0.20
11 families with at least 100 plants					3498	202	231.25	1.97

TABLE II. Albino seedlings in selfed timothy families.

Family	Mother Plant	Generation of selfing	No. of seeds	% germination	Number of seedlings found green	albino	Expected albino	P
			63 : 1 segregations					
13-1	13	I_1	74	91.89	67	1	1.06	0.06
19-4	19	"	200	83.-	164	2	2.59	0.36
30-1	30	"	164	81.71	131	3	2.09	0.64
79-1	79	"	62	75.81	47	1	0.75	0.29
710-1	710	"	60	101.67	60	1	0.95	0.06
F5-1	$F5_{61}$	"			146	2	2.25	2.00
F29-1	$F29_{68}$	"	61	90.16	53	2	0.84	1.34
F56-1	$F56_3$	"	210	61.90	128	2	2.03	0.02
F14-3	$F14_{29}$	"	150	97.33	145	1	2.38	0.85
F78-1	$F78_1$	"	444	87.16	382	5	6.05	0.43
F8-2	$F8_3$	"			451	3	7.09	1.84
F8-5	"	"			591	8	9.27	2.41
F8-6	$F8_4$	"	310	85.16	201	1	3.16	1.22
F8-8	$F8_5$	"	142	90.85	128	1	2.02	0.72
F8-9-4	$F8-9_4$	I_2	180	80.-	142	2	2.25	0.17
F38-1-2	$F38-1_3$	"	80	72.-	55	1	0.84	0.89
3-1-1	$3-1_3$	"	510	91.37	464	2	7.28	1.97
3-1-4	$3-1_6$	"	300	93.67	279	2	4.39	2.08
3-1-5	$3-1_9$	"	138	87.41	117	1	1.84	0.62
13-1-2	$13-1_{12}$	"			568	3	8.92	2.-
54-1-1	$54-1_{21}$	"	50	102.-	50	1	0.80	0.22
77-1-1	$77-1_{37}$	"	58	89.66	51	1	0.81	0.21
10-1-4-4	$10-1-4_1$	"	81	46.91	37	1	0.59	0.84
19-1-1-1	$19-1-1_{13}$	"	679	64.80	434	6	6.88	0.34
All families					5270	47	83.08	3.99
6 families with at least 300 plants					3436	23	54.02	2.87

TABLE III. Segregations from new and old seed.

Family	New seed Number of seedlings	% albino	Old seed Number of seedlings	% albino
F8-11	150	17.33	177	21.47
10-1-4	138	1.45	378	10.14
F8-2	147	0.68	484	0.67
F8-5	146	0.68	447	0.22
F8-6	119	0.84	50	2.04
13-1-1	107	3.74	75	0.-
13-1-2	191	0.-	380	0.79
30-1	99	3.03	35	0.-
19-4	166	1.20	264	0.-
F5-1	191	0.-	384	0.26
3-1-1	84	1.85	263	0.38
9 families 63:1 segr.	1307	1.08	2413	0.46
	1 year old		3 year old	
Grindsted	2361	0.085	3468	0.115

TABLE IV. Yellow seedlings in selfed timothy families.

Family	Mother Plant	Generation of selfing	No. of seeds	% germination	Number of seedlings green	yellow	Expected yellow	P
			15 : 1 segregations					
F8-9-4	$F8-9_4$	I_2	180	78.89	136	6	9.47	1.17
F35-2	$F35_{47}$	I_1	37	75.67	27	1	1.87	0.66
2 families			217	78.34	163	7	11.33	1.33
			63 : 1 segregations					
102-1	102	I_1	75	97.33	72	1	1.14	0.12
F56-1	$F56_3$	"	213	83.57	177	1	3.73	1.08
3-1-2	$3-1_3$	I_2	36	100.-	36	1	0.56	0.60
F8-9-1	$F8-9_{10}$	"	322	82.92	270	1	4.23	1.88
F8-9-2	$F8-9_7$	"	60	70.55	42	1	0.67	0.41
F8-9-3	$F8-9_1$	"	300	72.67	215	3	3.41	0.19
19-1-1-1	$19-1-1_{13}$	I_3	589	64.40	362	4	5.86	0.61
7 families			1565	74.89	1163	12	18.36	1.80
601-1 1937	601	I_1	180	93.33	140	0		
" 1938	"		300	92.-	275	1		
			480		415	1	6.50	2.17

TABLE V. Yellow-green seedlings in selfed timothy families.

Family	Mother Plant	Generation of selfing	No. of seeds	% germination	green	y.-green	Expected y.-green	P
			3 : 1 segregations					
F8-9-5	$F8-9_9$	I_2	300	72.67	164	51	53.75	0.43
10-1-4-1	$10-1-4_8$	I_3	47	55.32	20	6	6.50	0.22
2 families			347	69.45	184	57	60.25	0.48
			15 : 1 segregations					
F14-4	$F14_{36}$	I_1	116	84.40	89	9	6.13	1.20
F8-11-4	$F8-11_1$	I_2	44	86.36	36	2	2.38	0.25
2 families			160	85.-	125	11	8.50	0.88
			63 : 1 segregations					
F65-1	$F65_{39}$	I_1	42	93.02	39	1	0.63	0.47
F8-11	$F8_2$	"	300	97.67	289	4	4.11	0.06
F5-1-1	$F5-1_{44}$	I_2	801	85.64	676	10	10.72	0.32
19-1-1-1	$19-1-1_{13}$	I_3	559	63.69	344	8	8.80	1.07
4 families			1703	78.74	1318	23	20.96	0.46

TABLE VI. Light green seedlings in selfed timothy families.

Family	Mother Plant	Generation of selfing	No. of seeds	% germination	green	lt.-green	Expected lt.-green	P
			3 : 1 segregations					
F5-1-1	$F5-1_{44}$	I_2	801	85.64	505	171	169.-	0.18
F8-9-4	$F8-9_4$	"	180	78.89	107	29	34.-	0.99
2 families			981	82.77	612	200	203.-	0.24
			15 : 1 segregation					
0_1 260-1	0_1 260	I_1	364	51.92	177	12	11.81	0.06
			63 : 1 segregation					
19-1-1-1	$19-1-1_{13}$	I_3	589	64.40	345	7	8.80	0.64

TABLE VII. Families segregating for two or more deficiencies.

Family	Number of seedlings green	light green	yellow green	yellow	albino	total	
F56-1	127			1	2	130	
Expected	125.99			1.98	2.03	130	K^2=0.49 P=0.79
F8-11	259		4		64	327	
Expected	241.41		3.84		81.75	327	K^2=6.08 P=0.05
10-1-4-1	20		6		2	28	
Expected	19.69		6.56		1.75	28	K^2=0.088 P=0.95
F5-1-1	505	171	9		52	737	
Expected	510.10	170.04	10.80		46.06	737	K^2=1.122 P=0.77
F8-9-4	107	29		5	2	144	
Expected	99.65	33.22		6.88	2.25	144	K^2=2.039 P=0.57
19-1-1-1	291	7	4	2	4	308	
Expected	289.07	4.59	4.64	4.74	4.81	308	K^2=3.080 P=0.55
F8-9-5	164		51	3		218	
Expected	160.95		53.65	3.40		218	K^2=0.236 P=0.90

9,971 green and 8 albinos, that is, 0.000,8 per cent. On the assumption of free intercrossing between all types and no selfing, the expected frequency of albinos as calculated from the frequency of heterozygous types would be 0.106, which is not very different from the value found. Therefore, the frequencies of heterozygous plants found seem to represent roughly the actual conditions in this strain. It must be noted that the plants tested do not represent an unbiased sample of the strain, but have been selected for vigor and for other valuable plant characters from a point of view of breeding. We may have selected in this way the most heterozygous plants. On the other hand, selection for self-fertility is unavoidable in such material and may have caused us to pick out lines that have been for some generations largely selfed and which would be expected to contain fewer heterozygotes.

Selfing in Open-Pollinated Timothy

Very little is known about the degree of spontaneous self-fertilization in timothy under normal open-pollinated conditions, and very different assumptions have been made by various authors. If selfing is common, one should expect to find chlorophyll deficient seedlings in open-pollinated offspring from plants known to be heterozygous. We have found albinos in varying ratios in such families. One family from a single heterozygous mother plant has given 71 seedlings and no albinos, nine families from a double heterozygote 518 green : 8 albinos, and 21 families from triple heterozygotes have given 1,896 green : 5 albinos. From these numbers are calculated a selfing percentage of 18.03. This value is, of course, uncertain and very probably too high. In the first place, the plants tested are relatively self-fertile types, whereas the majority of plants produced only a few seeds by selfing. Further, the plants tested were grown single-spaced in family groups surrounded by sister plants. A large part of the pollen may have come from heterozygous sister plants and the albinos due to such crosses. In common seed fields of timothy the chances of selfing are evidently less than in spaced plants and selfing in such fields is evidently very low. In support of this assumption is the low frequency of albino seedlings from common seed of Grindstad.

Summary

1. In hexaploid timothy the following chlorophyll deficient seedlings have been demonstrated: albino, yellow, yellowish white with green streaks, yellow green, and light green.

2. Normal green is completely dominant. For all types, except for the yellowish white type, three apparently independently inherited homomeric factors have been shown to be present. A plant is normal green if only one of these factors is in a heterozygous condition.

3. Calculation is made of the frequency of plants heterozygous for chlorophyll deficiencies in a local Norwegian timothy strain. Calculation is made of the probable amount of spontaneous selfing in open-pollinated single spaced plants of the same strain.

4. Attention is directed to the fact that in timothy three, and not more than three, homomeric factors have been found, supporting the view that polyploidy is the basis of homomery.

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HYPERMOBILE JOINTS IN ALL DESCENDANTS FOR TWO GENERATIONS

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THE character is variously known as hypermobile—flexible, extensible, and double joints. According to Ebstein,[2] the hypermobility is due to a general slackness or abnormal flexibility of the ligamental apparatus or parts thereof, and may involve the joints of the knees, wrists, hips, elbows and toes but more commonly those of the fingers and thumbs. Structurally the ligaments and joints are normal.

Reports in the literature indicate that the character is variable in degree of expression and in number and kind of joints affected and likewise in its mode of transmission. Ebstein states that the abnormality shows an inherited tendency but does not elaborate on its mechanism of inheritance. Hanhart in communications reported by Baur, Fischer and Lenz[1] asserted that the peculiarity in some cases was dominant, and reported that he was able to compile a family tree showing it in twenty members of the kinship. Key[4] observed the abnormality in the father and four sons but not in the five daughters. The degree of hypermobility in the sons was extreme and involved a considerable number of different joints; it was also associated with club feet. Key stated, however, that there was no tendency to dislocation of any of the joints. The nine brothers and one sister and the parents of the double jointed father were normal. This case according to Gates[3] appears to reveal a male to male or holandric type of inheritance, wherein transmission is only through the *Y*-chromosome.

Whitney[5] presented a pedigree of double joints in thumbs, purporting to show that the character is inherited as a simple recessive; however, in the opinion of the writer, his data do not warrant his conclusions. In his case, only the thumbs exhibited the trait, and they not to a marked degree.

Report of Cases

This report is concerned with the analyses of two pedigrees, Figure 10*A* and 10*B*. Pedigree *A* represents a more complete and extensive study of the character, and hence most of the following account pertains to it.

It is noted in pedigree *A* that all decendants of II-4, comprising five in III and four in IV, show the hypermobility. Descriptions of the character with respect to degree of expression and kind and number of joints involved in the different individuals follow. Photographs of some of these variations are seen in Figure 9.

Generation II. II-4, the only abnormal member of four (See Figure 9), shows the hypermobility only in the fingers and thumbs, particularly the latter, where they could be bent backwards but not to the dorsum of the hand. She states, however, that these joints are not as flexible now as they were in her youth.

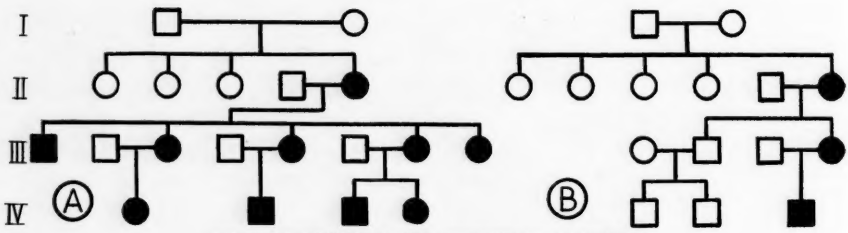
Generation III. All members of this generation show hypermobility, in varying degrees, of the joints of the fingers, thumbs, knees and elbows. Four of the five members show considerable mobility of the hips, while four of them show marked flexibility of the toes at the proximal joints; in some cases to the extent of being able to bend the toes to the dorsum of the foot. The joints of the fingers involved are the first and second, whereas only the proximal joint of the thumbs are apparently concerned. All individuals are able to bend the thumbs to the back of the hands. The joints of the knees and elbows of those affected are capable of

FLEXIBLE FINGERS
Figure 9

Examples of the joint mobility of individuals in the third and fourth generation shown in the pedigree chart, Figure 10*A*. The knee and elbows are also in varying degrees "double jointed."

contra-flexure to some extent. All of the joints mentioned above of III-1, the only male of this generation, are hypermobile, and to a greater extent than exhibited by his sibs. He can assume, with little effort, the appearance of a cripple by hyperextending and maneuvering various joints simultaneously.

Generation IV. Among the two boys IV-2 and IV-4 (ages 5 and 4½ years, respectively) both show the hypermobility in the thumbs and fingers (See (See Figure 9) ; moreover IV-2 exhibits the mobility in toes, but not in elbows or knees. The knees and elbows of IV-4, however, are affected, but the condition of his toes was not ascertained. The girls, IV-1 and IV-3 while only eighteen months and thirty months of age show the hyperflexibility in the fingers and thumbs, especially the latter. The knees, elbows and toes of IV-3 also exhibited a high degree of mobility. At these ages it is known that the phalangeal and other joints show a greater degree of mobility than at more advanced ages, but not to the extent characteristic of the above.



TWO PEDIGREES OF "DOUBLE JOINTS"

Figure 10

Pedigree *A* is noteworthy in that all the sibs in Generation III and IV show the characteristic.

Pedigree B, like *A,* shows the presence of the trait in three generations, but the number of individuals involved is smaller. Here, as in *A*, only one individual in generation II showed the character; moreover there was no record of its occurrence in previous generations. Among the three descendants of II-5, one of the two in III and the one in IV exhibited the hypermobility only in the fingers and thumbs. The degree of mobility, however, particularly in the thumbs was not as great as that described for case *A*. The two sons of III-1, the normal member, are likewise normal.

Discussion

It is obvious from the study of these and other pedigrees that transmission of the character is irregular. No attempt is made to ascribe to its mode of inheritance one or a number of genes. It is clear from the analysis of case *A* that the trait is not inherited as a simple recessive, as Whitney concluded; furthermore, it is difficult to conceive of a factorial scheme embracing dominant genes which will satisfactorily explain its behavior. Taking into account only the evidence presented by this study, one is apt to perceive a maternal influence in the transmission of the anomaly, since it was transmitted in both cases (*A* and *B*) only through the females. But when it is recalled from the reports of Key and Whitney that the character can also be handed down through the male, such reasoning does not hold, assuming that the same gene is involved in all four pedigrees.

The character is subject to considerable variation in expression as reports have indicated. This might well be expected of a physiological character, particularly one involving, most likely, some general disfunction of the ligamental apparatus and having its origin in the embryonic stages of development. Our lack of knowledge concerning the conditions involved in the developmental stages of this character appears to the writer to preclude a satisfactory explanation of its mode of inheritance.

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THE INHERITANCE OF EQUINE COAT COLOR

The Basic Colors and Patterns*

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IN the course of investigations to determine the mode of inheritance of the Palomino color, which has recently become popular among horsemen, especially in the Southwest, it became necessary to obtain additional information regarding the inheritance of the more common colors. This was done by a study of the color of individual ponies registered in the American Shetland Stud Book and their sires and dams. Color requirements for registration in this breed have not been applied, and it is believed that this tends to reduce to a minimum the bias usually found in such volumes of record for inheritance studies. To shed some light on the inheritance of some specific colors, a study of the color of horses registered in the Stud Book for Finnish Horses (Stambok För Hästar av Finsk Ras) was made. In the case of face and leg markings, an additional study was made of the markings of Thoroughbred horses registered with the Jockey Club.†

Information on body color, color of the mane and tail, white markings, and other patterns have been included in this study. In some cases the data presented on the inheritance of certain of these characteristics are meagre, in other cases more data are presented than have been available previously.

The Basic or Foundation Colors

From this investigation it appears that the basic or foundation colors may be listed as:

1. *Bay.* A bay horse or pony is one having a black mane and tail, black feet and legs, the black often extending as high as the knees and hocks, and a red-colored body of several different shades, which may vary from a light bay through the various intermediate shades to a dark, cherry red.

2. *Brown, brown-black or seal brown.* The brown color is sometimes confused with bay and, if the individual is especially dark, may be confused with black. It is accompanied by black mane, tail, feet, and legs. The body is brown varying to black, but the muzzle, the region about the eyes, the flanks and the underlines, especially in the groins, are a lighter shade of brown. These "light points," as they have been identified by Gremmel[4], are variable in extent and intensity of pigmentation. This fact has led to confusion in the identification of animals for registration purposes and explains the rather high proportion of browns resulting from the black × black mating shown in Table I.

3. *Black.* Black is a uniform color found most commonly in the Percheron breed of horses and Shetland ponies. It is particularly subject to bleaching in sunlight. Bleached-black horses exhibit a marked red tinge to the hair which approaches bay or brown in color.

4. *Chestnut.* This color is variable in shade and is generally broken into three classes: the liver chestnut, the chestnut, and the sorrel. This group is characterized by a reddish-brown color varying in shade from a dark chocolate, in the case of the so-called black chestnut and liver chestnut, to the lighter, reddish, golden-brown of the sorrel. There is much confusion in the designation of these colors. Saddle horse breeders usually refer to all ot these colors as chestnut, while the draft horse breeder and the western stockman often classify all but the liver chestnuts as sorrels.

The mane and tail of this color group is the same color as the body, or lighter. In some cases the mane and tail may be nearly a perfect white. This is an independently inherited characteristic and occurs on each of the shades of chestnut. The pasterns and legs are generally lighter in shade than the body. The color is lightest around the hoof-heads and fetlock joints, becoming progressively more like the body color farther up the leg.

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†This study was made possible by the Registry Office of the Jockey Club, which made their records available to Howard S. White. The author is indebted to Mr. White for the data.

Inheritance of the Basic Color in Shetland Ponies

Table I gives the data obtained from the study of Shetland matings. In the columns of the table headed "A" are presented the results obtained when only self-colored ponies, or those with limited white markings, were used. Such ponies might conceivably be more easy to classify regarding color than would ponies having extensive white markings. The data presented in the columns headed "B" are based on a study of spotted ponies. If the sire, the dam, or the progeny possessed extensive white spots and the body color was stated in the Stud Book, the data were placed in this part of the table.

Under "others" in this table are included such colors as roan, gray, dun, and mouse, which could not have been produced by the matings considered in Table I if our theories are correct. These may have been a result of improper identification of the foal, the sire, or the dam. In this connection, it must be borne in mind that color in any individual is not standard but may vary with age, season, and exposure to sunlight. For example, horses which later are black are usually a peculiar mouse-brownish-gray color at birth. This disappears with the foal hair. If black horses are subjected to intense sunlight the color may be bleached to a reddish tinge which is not far different from bay. Occasionally an individual may be jet black when foaled with the color changing little, if any, when the foal hair is shed. This, however, is the exception.

There seems to be no important discrepancy in the data presented in the two sections of the table except that in section *B* there is too high a proportion of bay, brown, and black ponies resulting from the chestnut or sorrel matings with chestnut or sorrel. This was not unexpected, for white spots extending over a considerable portion of the body undoubtedly render exact identification of body color difficult. Even when no hazards of identification are introduced, some horsemen confuse chestnut, sorrel, bay and brown colors.

The results presented are in general agreement with the data presented by other investigators[1,5,8,9,10,12] and indicate that the mode of inheritance of the basic colors is the same in Shetland ponies as in their larger counterparts. The data emphasize the importance of the brown color in this breed. The unexpectedly large number of browns and bays recorded from the black × black mating is undoubtedly due in part to the fact that some of the so-called black parents actually were brown-black and should have been registered as browns. Another factor may be that the ponies were registered before the foal hair had been shed, and thus the color was improperly identified. Wilson[12], in a study of Clydesdales and Thoroughbreds, found that most horses registered as blacks were actually browns when closely examined. The author has examined a large number of progeny from uniform black × uniform black matings where the parents have been positively identified. Not one of the progeny was bay or brown. The progeny seen have been blacks, chestnuts, or sorrels.

In regard to the matings of sorrel and chestnut individuals with those of the same and other colors, the results previously reported by McCann[7] for horses and the results shown in Table I for ponies show striking agreement. McCann's data were based on 427 such matings, while 3,235 are reported in this paper.

No attempt has been made by Shetland pony breeders to distinguish between liver chestnut and the usual chestnut color. While the author has had the opportunity of studying these two shades of color by direct checking of all animals concerned in the Cornell University stud, it was felt that additional information was necessary. The Stud Book for Finnish Horses (translated title) offered the opportunity for additional study, for a large proportion of the animals recorded are of the various shades of chestnut and sorrel.

The results of this study are given

in Table II. The colors which are included under "others" are those which, when translated from the Finnish, could not be classified satisfactorily. They include such colors as those which, when translated literally, mean "dirt brown," "wolf brown," etc.

These data are confusing but tend to bear out the generally observed fact that liver chestnuts are definitely in the minority in any population of chestnut and sorrel horses.

When the difficulties encountered by American horsemen regarding the designation of a horse as chestnut or sorrel are considered, it is not strange that others should have this difficulty. However, the information on Finnish horses is of considerable value as a means of obtaining an answer to the next problem which is considered.

TABLE I. INHERITANCE OF LIVER COLORS IN SHETLAND PONIES

Color of parents	Color of offspring: Bay	Brown	Black	Chestnut	Sorrel	Flaxen	Total nos.
Bay x Bay	[illegible]						
Bay x brown	[illegible]						
Bay x black	[illegible]						
Bay x Chestnut	[illegible]						
Bay x Sorrel	[illegible]						
Brown x Brown	[illegible]						
Brown x Black	[illegible]						
Brown x Chestnut	[illegible]						
Brown x Sorrel	[illegible]						
Black x Black	[illegible]						
Black x Chestnut	[illegible]						
Black x Sorrel	[illegible]						
Chestnut x Chestnut	[illegible]						
Chestnut x Sorrel	[illegible]						
Sorrel x Sorrel	[illegible]						

a. Data on self-colored ponies and those with limited white marking only

b. Lots on spotted ponies.

TABLE II. INHERITANCE OF LIVER CHESTNUT, CHESTNUT, AND SORREL

Color of parents	Color of offspring: Liver chestnut	Chestnut	Sorrel	"other"	Total
Liver chestnut x Liver chestnut	22	8	15	2	47
Liver chestnut x chestnut	114	64	162	17	371
Liver chestnut x sorrel	69	42	212	9	332
Chestnut x chestnut	54	195	348	24	700
Chestnut x sorrel	105	257	662	23	1247
Sorrel x sorrel	27	128	322	10	487
	446	694	1726	85	3184

TABLE III. INHERITANCE OF WHITE MANE AND TAIL IN SHETLAND PONIES

Color of parents	Color of offspring: Chestnut or sorrel	Chestnut or sorrel with white mane and tail	Total
Chestnut or sorrel x chestnut or sorrel	81	27	108
Chestnut or sorrel x chestnut or sorrel white mane and tail	48	28	76
Chestnut or sorrel white mane and tail x chestnut or sorrel white mane and tail	4	32	36
	133	87	220

TABLE IV. INHERITANCE OF LIMITED WHITE MARKINGS

Parents	Breed	Offspring: Solid	Marked
Solid x solid	Shetland	5011	537
	Finnish	447	155
	Thoroughbred	6	10
Solid x markings	Shetland	1172	306
	Finnish	430	1245
	Thoroughbred	29	73
Markings x markings	Shetland	60	55
	Finnish	266	994
	Thoroughbred	29	1

The Inheritance of White, Silver, or Flaxen Mane and Tail

Of considerable interest to many horsemen is the question of the mode of inheritance of the white, silver, or flaxen mane and tail characteristic found in chestnuts, and sorrels. The white mane and tail trait is characteristic of the Palomino, but its inheritance will be dscussed in a later paper.

The mane and tail color of horses or ponies of the chestnut group varies from the same color as the body to an almost pure white. The light mane and tail characteristic in Belgian horses has been studied by Wentworth[11], who reported data from which he drew the conclusion that it was a monofactorial recessive to the normally pigmented mane and tail. That the mode of inheritance of this characteristic is more complicated is indicated by the present study. The data obtained on Shetland ponies are presented in Table III.

Regardless of the color of the sire or dam, 36.7 per cent of the chestnut and sorrel ponies were registered in the Stud Book as having a light mane and tail. No evidence could be found to indicate that the white mane and tail characteristic was inherited differently in the chestnut than in the sorrel; so the combined data are presented in the table. However, in the Finnish horses 32.6 per cent of the chestnuts and 30.3 per cent of the sorrels were reported as having a white mane and tail. On the other hand, only 9.6 per cent of the liver chestnuts showed this character. An analysis of over 3,500 pedigrees indicates that the problem is more complicated in this breed. It appears that at least two recessive pairs of genes in the homozygous condition are necessary for the expression of the white mane and tail characteristic in liver chestnut horses. It would appear that there are additional genes which modi-

fy the shade of the coat and also tend to influence the amount of pigment in the mane and tail.

The Inheritance of Patterns and Markings

There are a number of genes which are epistatic to the basic colors of horses. Among these epistatic genes may be mentioned those responsible for the gray color, roaning, spotting, dominant white color, and dilution of the basic colors. The dilution gene will be discussed in a later paper.

Gray is considered to be a basic or foundation color by some investigators. This conclusion is not upheld by this study. Gray horses or ponies are black at birth. The white hairs appear when the foal hair is shed, and the individual becomes progressively whiter with age. Horses known to be homozygous from breeding results turn white more rapidly than do those which are heterozygous. When gray Shetlands were mated with individuals of the basic colors a 1:1 ratio of gray to the basic colors resulted from 106 such matings. In Percheron horses the mating of grays results in a preponderance of grays, while mating a gray with a black results in either all or approximately one-half gray progeny. However, one gray Percheron stallion has been observed which, when bred on black mares, produced foals, of which one-half were bay at birth and the others black. About one-half of the total turned gray later, while the remainder were either bay or black. From these observations it is concluded that gray is produced by a dominant gene epistatic to the basic colors.

Roaning is due to a gene which acts in a manner similar to that responsible for gray. However, it does not obscure the basic color so completely and is not influenced to so great an extent by the age of the animal. Mating of roans on the basic colors resulted in a 1:1 ratio of roans to the basic colors in 159 offspring in the Shetland breed. Three matings of roan on roan resulted in roan offspring.

In the Shetland there are two types of white spotting. One is a dominant white spotting where the white spots are extensive and found on any part of the body. It is found superimposed over gray, roan, dilute, or any of the basic colors, is variable in extent, and is undoubtedly influenced by modifying genes. One stallion with a small white spot on his breast produced as high a proportion of spotted foals as did another which was entirely white save for a small patch of chestnut on one cheek. Mating of spotted to spotted ponies resulted in 1,697 spotted ponies and 334 self-colored ponies. Mating of spotted on self-colored individuals resulted in 2,938 spotted to 2,711 self-colored ponies. From over seven thousand matings involving self-colored ponies or those with limited white markings only, the number of offspring possessing extensive white markings was 2.43 per cent. These results may be explained in part by errors, but do indicate that the recessive type of spotting, termed "splashed white" by Klemola,[6], may perhaps occur in Shetland ponies.

A record has been made of the inheritance of face and leg markings of the Shetland, Finnish and the Thoroughbred breeds. These are termed "limited white markings" and include the star, blaze, strip, and snip, as well as white markings on the legs, which vary in extent. The number of ponies or horses carrying the chin spot was too limited for conclusions to be reached on this character, which, according to Blunn and Howell[2], is inherited separately from the other markings. From a study of the data, it appears that the face and leg markings are definitely associated in inheritance; so no attempt was made in the following table to list the markings according to location or extent.

The records on Shetlands were obtained first and, as the data did not appear to agree with the results of others[2, 3], the data from the Finnish records were studied. These data emphasized what appeared to be a breed difference and demonstrated that lim-

ited white markings were probably not due to a single dominant gene. To check this matter further, the study on Thoroughbreds was undertaken, for in this breed rigorous rules regarding the identification of animals for registration and racing purposes are followed. Here again a similar picture was obtained.

It would appear from these data that limited white markings are dependent upon more than one pair of genes. It is possible that we here have manifested both a dominant and a recessive type of spotting in the same areas of the body, types which are indistinguishable in appearance and have thus been grouped together in this study. The difference between breeds may be partly explained by unconscious selection practiced in the development of these breeds.

Dominant white is of infrequent occurrence in horses or ponies. In fact, many so-called "white" horses are old homozygous grays. However, during recent years there has been an increased interest in the breeding of white horses, and the American Albino Horse Club* has been organized to record such individuals. White horses are pink skinned, and are entirely white in color save for an occasional individual possessing small areas of pigmented hair in the ears and other extremities. The eyes are usually dark brown or blue. That the character is due to a single dominant gene which is epistatic to all colors is indicated. For example, in one breeding establishment the breeding program was based on the progeny of one stallion, which produced one-half white progeny when bred to colored mares. When these white progeny were crossed about seventy-five per cent of the resulting offspring were white. Breeding of the F_2 females back to the grandsire resulted in producing an even higher percentage of white foals. At present the establishment is breeding all white individuals.

Some horsemen have confused dominant white with the effects produced by the homozygous condition of the dilution gene on chestnut or sorrel. There is no basis for the belief that they are the same character.

Summary

Data obtained from a study of stud book matings of Shetland ponies show that the mode of inheritance of the basic colors is similar to that reported for horses. The white mane and tail found on some chestnuts and sorrels are produced by recessive genes and are inherited independently of body color, though dependent for expression on the absence of a gene for black. The position of gray and roan in relation to the basic colors is discussed. The gene for dominant white spotting is widespread in this breed. Limited white markings have been shown to be due to more than one pair of genes in Shetland ponies, Finnish horses, and Thoroughbred horses. The occurrence of dominant white is reported.

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*I am indebted to the secretary, Mrs. Ruth Thompson, Stuart, Nebraska, for the information regarding this color and for hair samples from dominant white horses.

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THE EUCALYPTUS IN BRAZIL

(*Continued from page* 220)

at the ends. At first we thought that this defect was inherent only in Eucalyptus, but we have since learned that the defect is common to a great number of hardwoods. Various methods have been tried in the United States and Germany to overcome this characteristic. This is the reason why I have returned for the fifth time to your admirable country that I regard so highly, to ask again for your help and to use your knowledge again.

Hybrids

For a long time, Baron Ferd. von Muller, first director of the Botanical Garden of Sydney, Australia, and the author of the monumental "Eucalyptographia," thought it was impossible to hybridize eucalyptus, as the flowers are protected by the operculum until after they are fertilized. This was a mistake. Prof. L. Trabut, director of Agriculture in Algeria, French Africa, has obtained different hybrids now known as *E. trabuti, E. algeriensis, E. antipolytensis,* and *E. oranensis.* In my experiments in Brazil, I have also many hybrids, with two or three very remarkable. One of them, the best one, is *E. paulistana,* obtained by natural breeding between *E. globulus* and *E. robusta.* Very interesting is the fact that its parents are not good species for Brazil, while the hybrid is a very fine tree with all the virtues of its parents, but without their defects. The *E. paulistana* has the rapid growth of *globulus* and is much taller than *robusta.* I have now trees from the fifth generation and without any variation since the third generation. Their bark is not so thick and corky as that of *robusta* and the fibers are straight and not like cork-screws, as in the *globulus.* It grows well in different conditions of climate and soil.

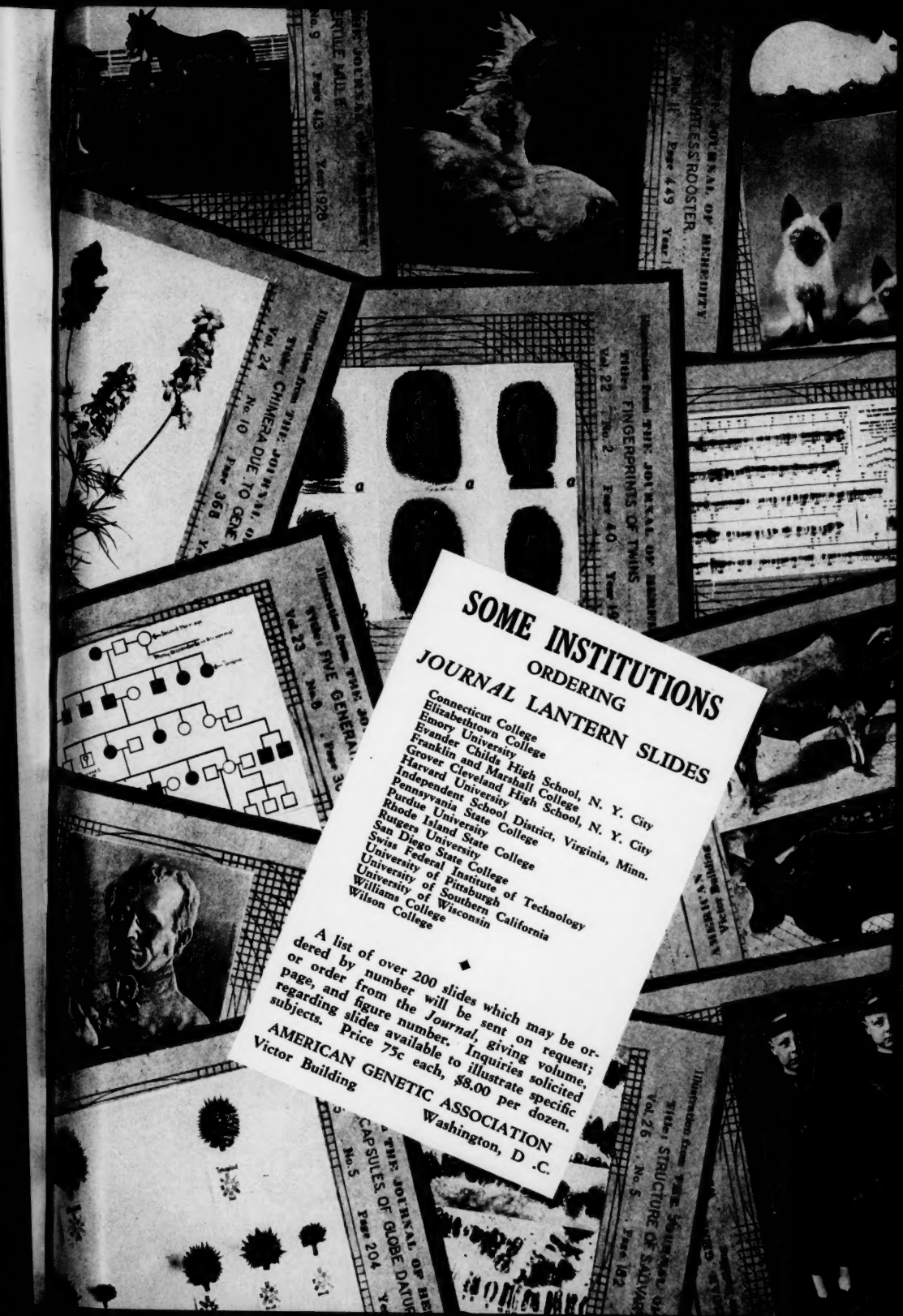
Since such a great number of species of eucalyptus exist in nature, it has been simpler to find the species best adopted to Brazilian conditions and to use them in our work. Thus there has been no urgent need to carry on hybridization experiments. The high quality of the *paulistana* hybrid and the absence of variation after the third generation suggests there are practical and theoretical possibilities in controlled hybridization experiments that would reward further study.

God willing, problems will always arise in my career which will necessitate frequent visits to the United States, the country that I admire and love so much; which holds for me so many old and firm friendships.

◆

The "Shade" of Grape-Seeds-to-Come—A Correction

In the July JOURNAL the legend to Figure 9 was marred by two errors: Line four should read *self-fertility* for *self-sterility;* Line five should read *shape* for *shade.* The editor regrets.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